Appendix F-4 Figures and Tables

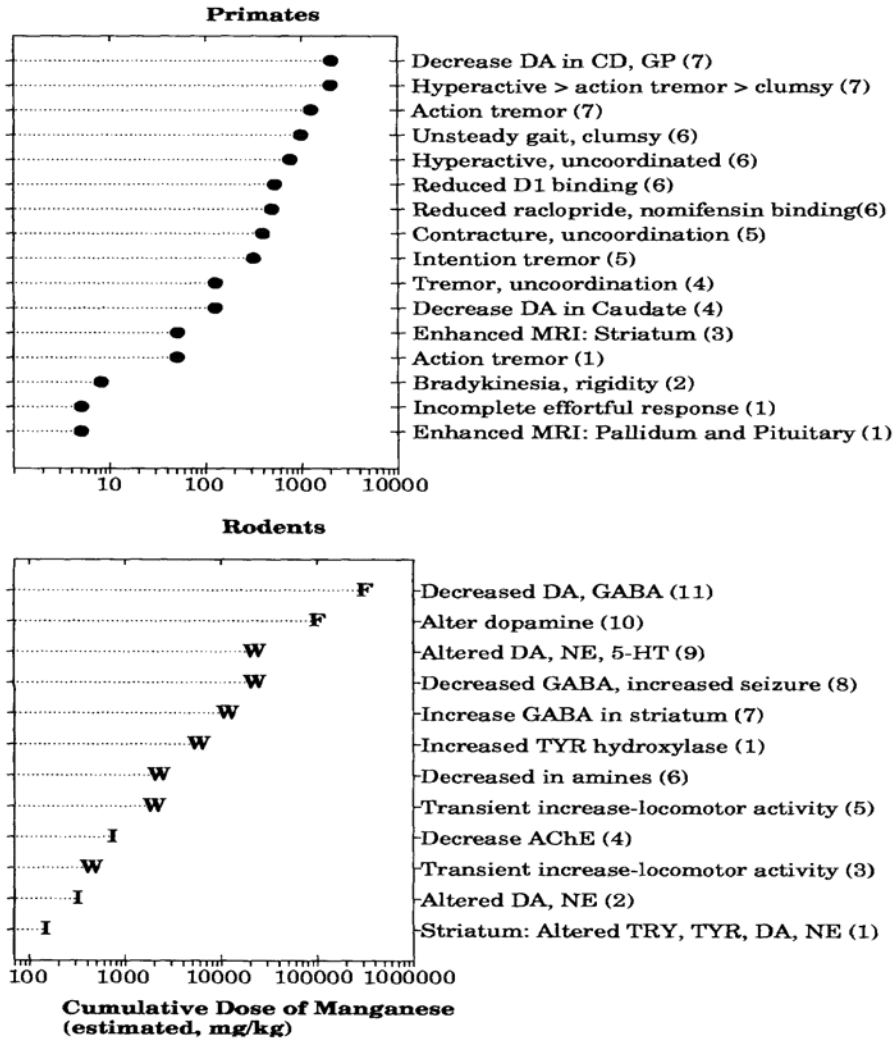


Figure 1. Relationships between administered manganese dose and indices of neurotoxicity in primates and rodents (Newland, 1999).

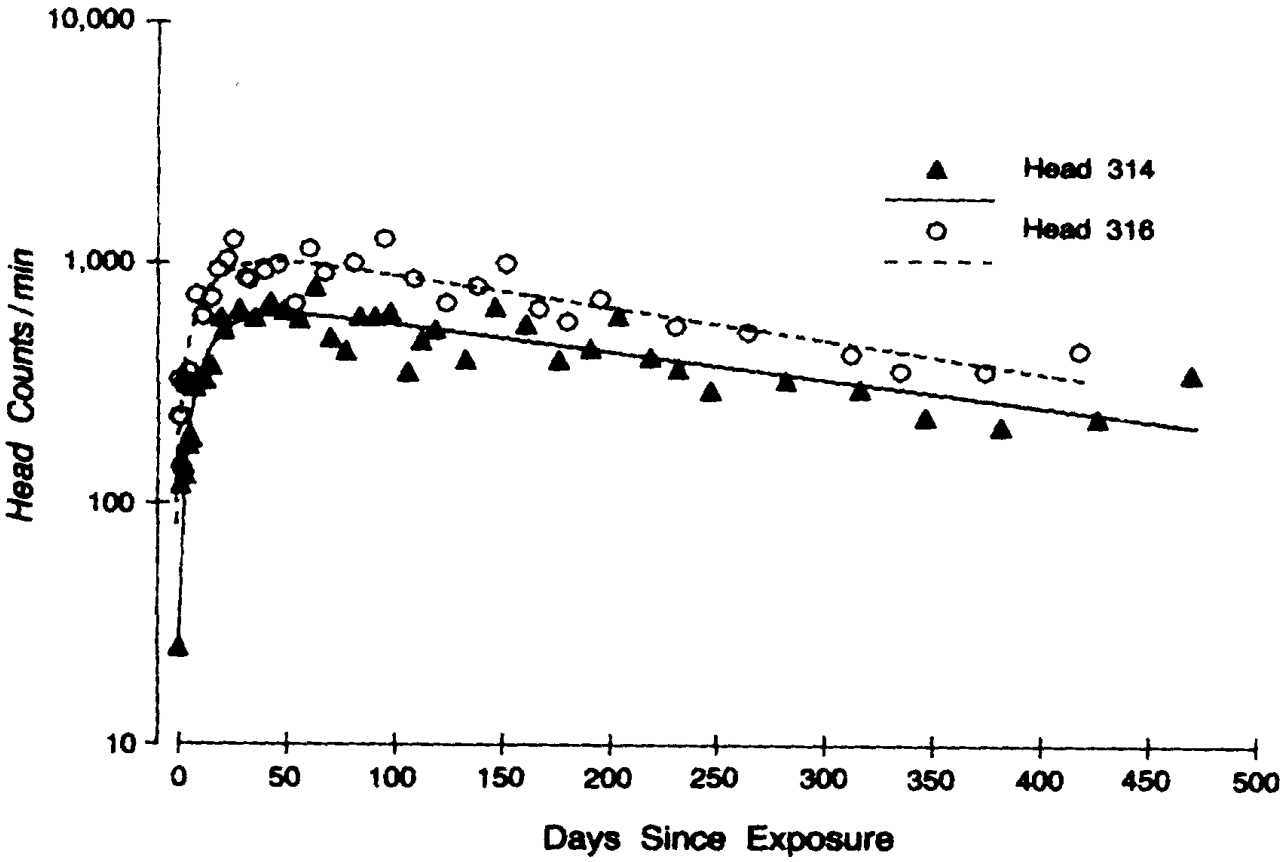


Figure 2. Radioactivity in the head after inhalation of ^{54}Mn in two monkeys (M. nemestrina). From Newland et al, 1987.

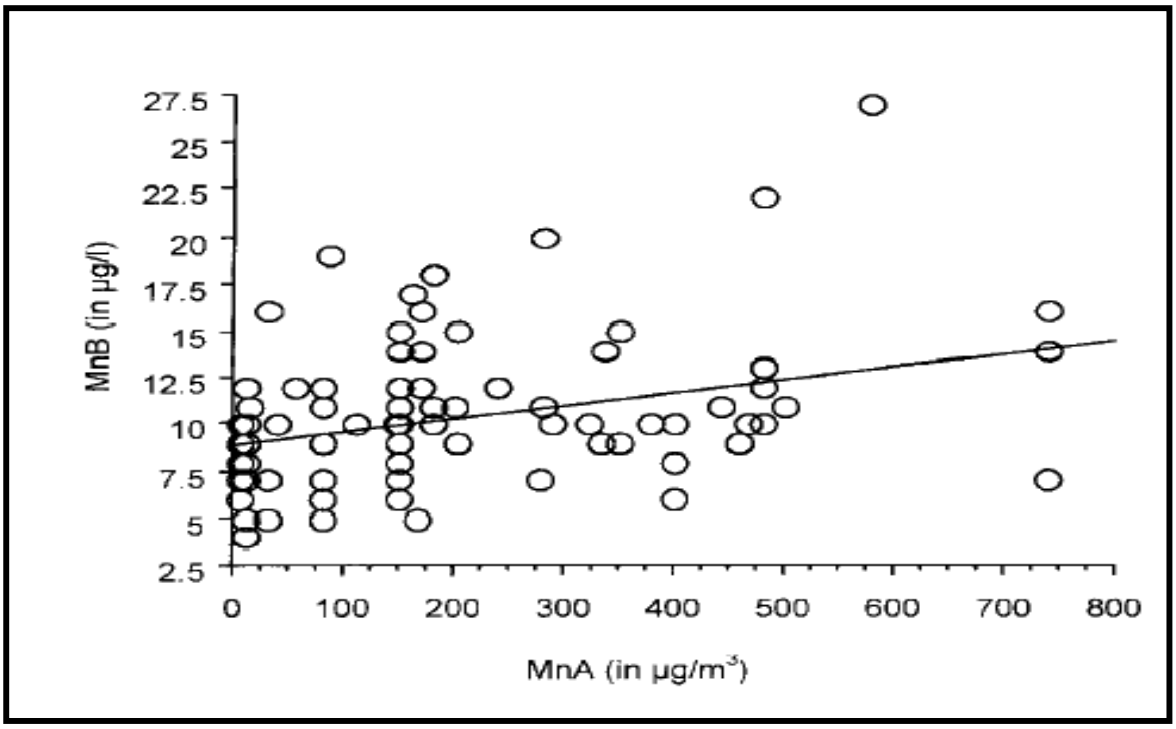


Figure 3. Relationship between air and blood manganese levels in exposed workers (Apostoli et al, 2000)

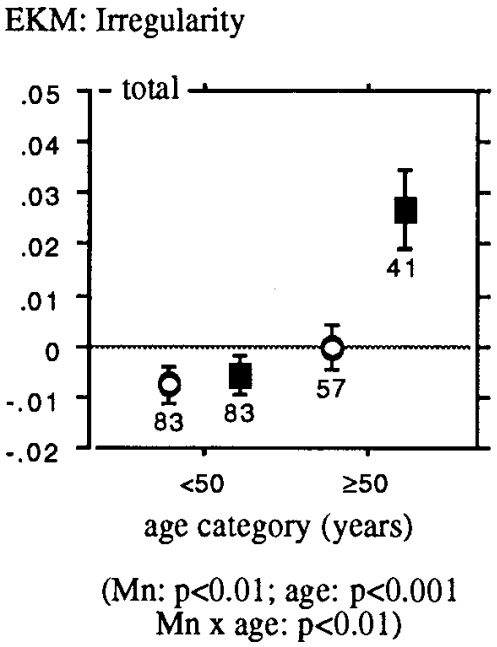


Figure 4. Performance on the Irregularity score of the task requiring alternate striking of spatially separated targets. Key: ■ = MnB > 7.5 µg/L. ○ = MnB < 7.5 µg/L. From Mergler et al, 1999.

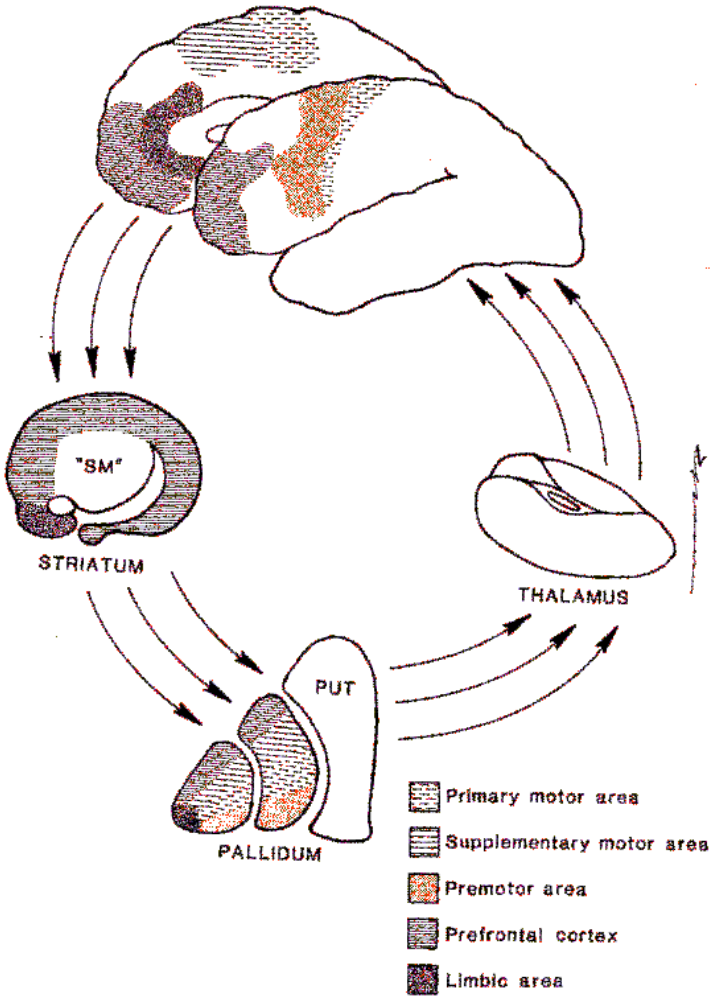


Figure 5. Globus Pallidus connections. PUT=putamen; SM=sensorimotor circuits.

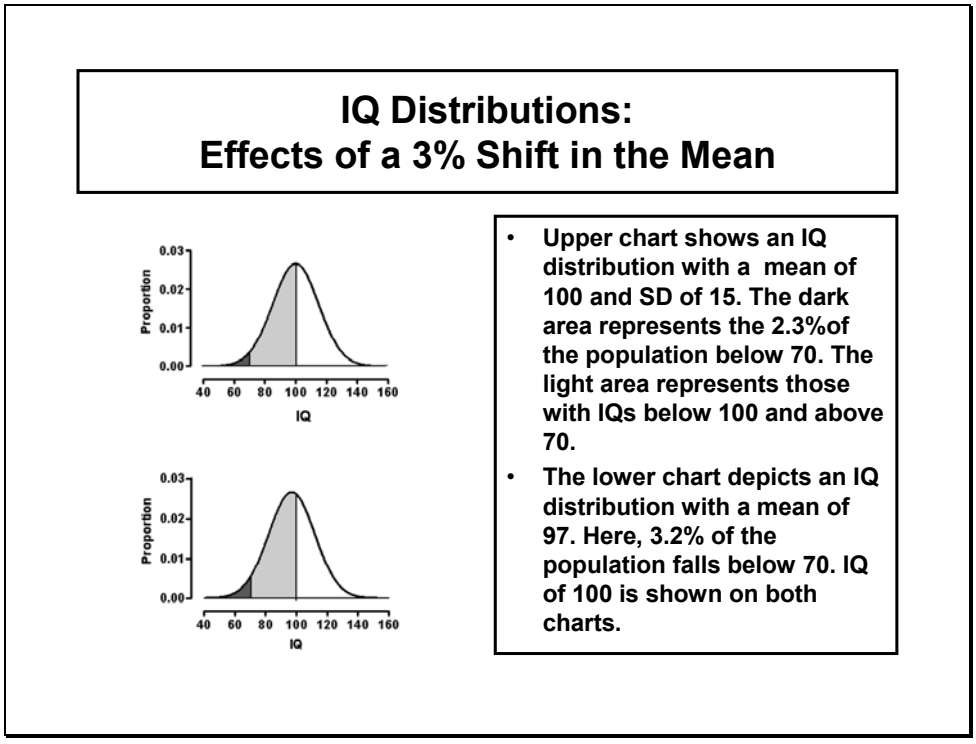
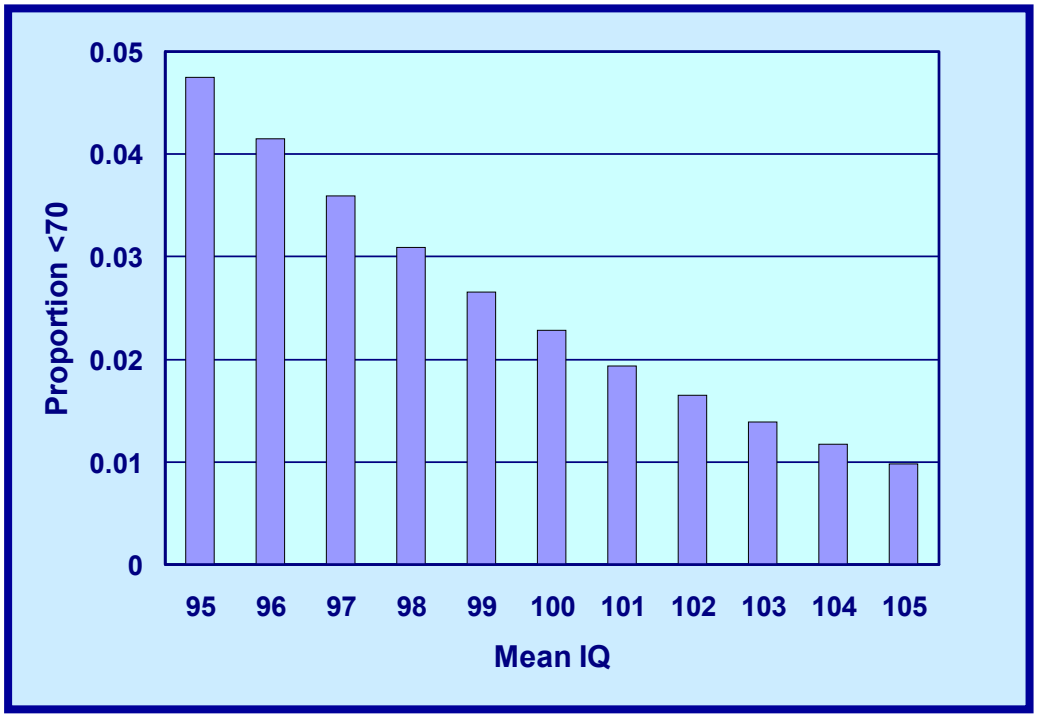


Figure 6. Consequences for classification of Mentally Retarded (IQ<70) of a 3% shift in the IQ distribution. From Weiss, 2000.

Figure 7. Proportion of Individuals in Retarded Range (IQ<70) with Different Population Mean IQ Scores



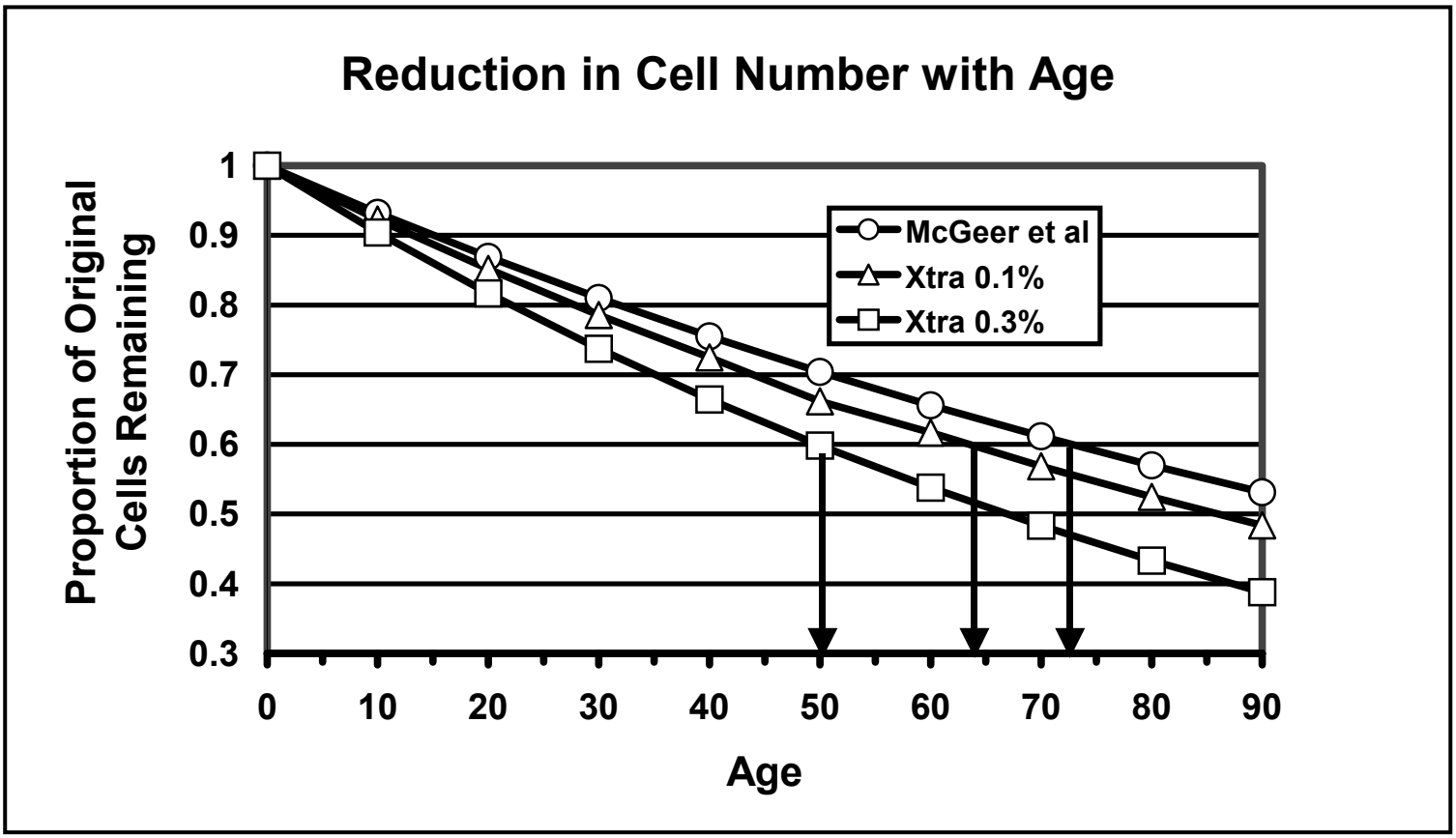


Figure 8. Cell loss with age in substantia nigra

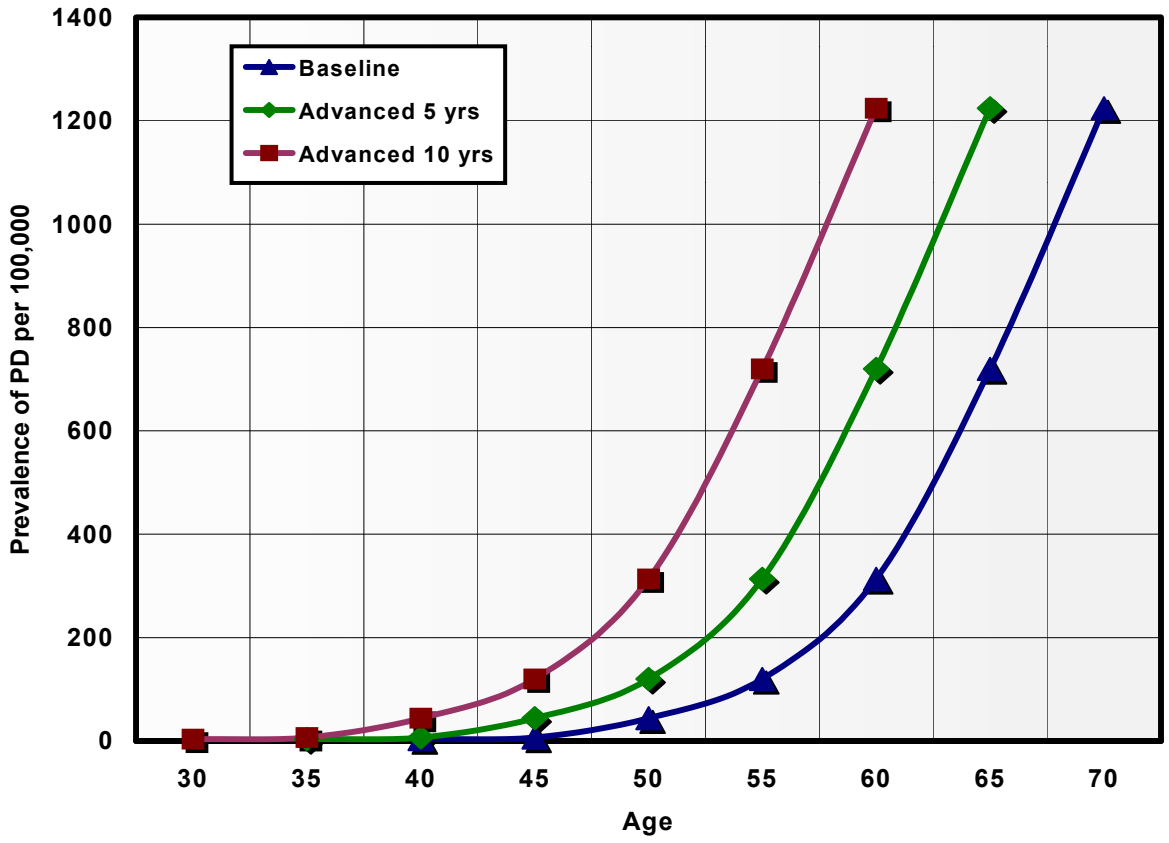


Figure 9. Acceleration of Parkinson's disease onset. From Weiss, 2000

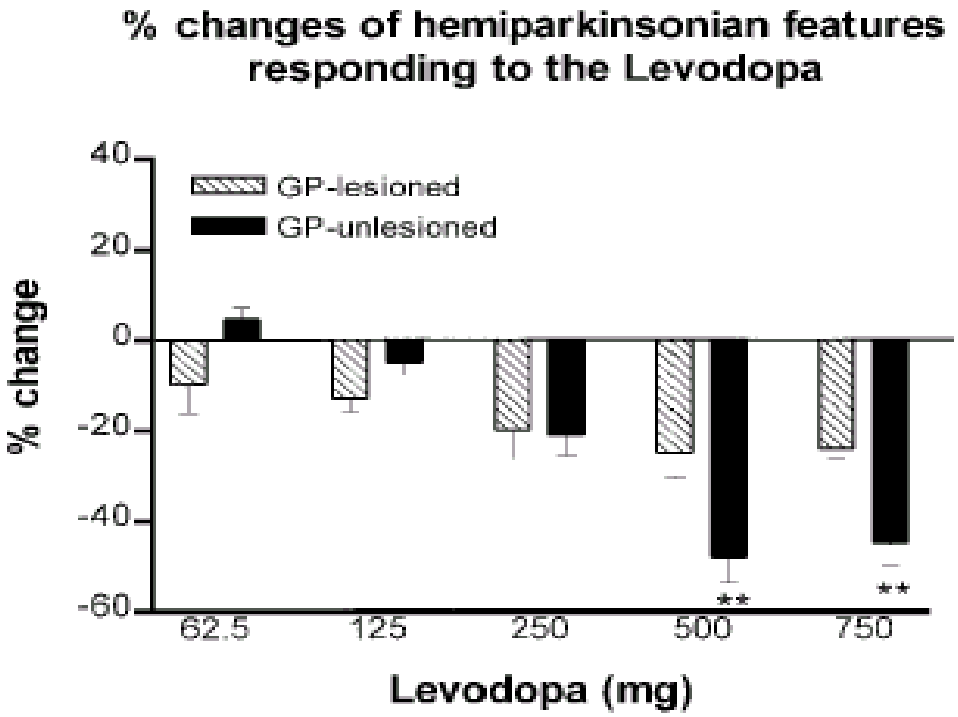


Figure 10. Comparison of therapeutic effectivenes of L-dopa in hemiparkinson monkeys with and without collateral pallidal damage.

Table 1. Signs and symptoms of manganese neurotoxicity

- Abnormal gait
- Impaired coordination
- Abnormal laughter
- Expressionless face
- Weakness
- Bradykinesia
- Somnolence
- Dysarthria
- Difficulty walking
- Clumsiness
- Lack of balance
- Muscle pains
- Diminished leg power

Table 2. (Mergler and Baldwin, 1997)

Demographics and Internal Exposure Parameters for a Number of Comparable Studies of Active Workers

Reference (exposed + controls)	Type of plant	Mean age of exposed	Years of exposure, mean ±SD (range)	MnB of exposed, geometric mean (μg/100 ml)	MnB of controls, geometric mean (μg/100 ml)	MnU of exposed, geometric mean (μ g/g cr)	MnU of controls, geometric mean (μg/g cr)
Roels *et al.* (1987) (141 + 104)	Mn oxide and salt	34.3 ± 9.6 (19–59)	7.1 ± 5.5 (1–19)	1.22*	0.49	1.59*	0.15
Wennberg *et al.* (1991) (30 + 90)	Steel smelting	46.4 (19–63)	9.9	—	—	—	—
Roels *et al.* (1992) (92 + 101)	Dry alkaline battery	31.3 ± 7.4 (22–49)	5.3 ± 3.5 (0.2–17.7)	0.81*	0.68	0.84*	0.09
Chia *et al.* (1993) (17 + 17)	Mn ore milling	36.6 ± 12.2	7.4 ± 4.3 (1–14)	2.53	2.33	6.1 μg/liter	3.9 μg/liter
Mergler *et al.* (1994) (74 + 74)	Ferro and silico alloy production	43.4 ± 5.4 (32–58)	16.7 ± 3.2 (1–17)	1.03*	0.68	0.73	0.62
Lucchini *et al.* (1995) (*n = 58*)[a]	Ferroalloy plant	38.9 (20–53)	(2–28)	1.19*	0.60	2.8 μg/liter	1.7 μg/liter

[a] Lucchini *et al.* compared 19 low-exposure workers to 39 more highly exposed workers.
* The authors report significant differences between those exposed and control ($P < 0.05$).

Table 3. (Mergler and Baldwin, 1997)

Results of Neurofunctional Assessment from Comparable Studies of Active Manganese-Exposed Workers

Reference (exposed + controls)	Motor functions	Hand steadiness	Response speed	Diadocho-kinesia	Memory	Other intellectual functions	Olfactory sensitivity	Mood state
Siegl and Bergert (1982) (25 + 21)	—	—	↓	—	—	—	—	—
Roels *et al.* (1987) (141 + 104)	↓	↓	↓	—	↓	—	—	—
Wennberg *et al.* (1991) (30 + 90)	↓	—	↓	—	↓	**n.s.**	—	—
Wennberg *et al.* (1992) (30 + 90)	—	—	—	↓	—	—	—	↓
Roels *et al.* (1992) (92 +101)	—	↓	↓	—	**n.s.**	—	—	—
Chia *et al.* (1993) (17 + 17)	↓	—	—	—	↓	↓	—	—
Mergler *et al.* (1994) (74 + 74)	↓	↓	**n.s.**	—	**n.s.**	↓	↑	↓
Beuter *et al.* (1994) (10 + 10)	—	—	—	↓	—	—	—	—
Lucchini *et al.* (1995) (n = 58)[a]	↓	—	**n.s.**	—	↓	↓	—	—

[a] Lucchini *et al.* compared 19 low-exposure workers to 39 more highly exposed workers.

Table 4. Blood manganese levels (µg/L) in exposed and control workers (Lucchini et al, 1999).

	Mean	Median	Range
Exposed	9.71	9.00	4-19
Control	6.00	6.00	2-9.5

Table 5. Blood manganese levels (µg/L) in the Quebec community study (Baldwin et al, 1999; Mergler et al, 1999)

	Mean	Median	Range
All	7.50		2.5-15.9
Women	7.90	7.70	2.8-15.9
Men	7.00	6.60	2.5-13.9

Table 6. Neuropsychological Measures used in the Quebec Community Study

- Eye-hand coordination
- Rapid pointing movements
- Tremor frequency and amplitude
- Neurological exam indices
- Learning and recall
- Mood
- Psychological symptoms
- Body sway

Table 7. Projected annual medical costs of Parkinson's disease, to age 74, based on age-related prevalence comparing baseline age distribution with onset accelerated by 5 years.

Age (2005)[1]	Number (x1,000)	Base PD	Base Cost (x$1,000)[2]	+5 PD	+5 Cost (x$1,000)	Difference (x$1,000)
35-39	**20,082**			**823**	**11,160**	**11,160**
40-44	**22,634**	**928**	**12,584**	**1,584**	**21,479**	**8,895**
45-49	**22,230**	**1,556**	**21,099**	**9,810**	**133,024**	**111,925**
50-54	**19,661**	**8,876**	**120,359**	**23,593**	**321,277**	**200,918**
55-59	**16,842**	**28,210**	**382,528**	**52,827**	**716,334**	**333,806**
60-64	**12,848**	**40,300**	**546,680**	**92,506**	**1,254,381**	**707,701**
65-69	**10,086**	**72,619**	**984,714**	**123,458**	**1,674,090**	**689,376**
70-74	**8,375**	**102,514**	**1,390,090**	**119,218**	**1,616,596**	**226,506**

[1]US Census Projections
[2] Based on Dodel et al (1998) @$13,560/yr